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REVIEWS

Problems and Prospects in Long and Medium Range Weather Forecasting. Edited by D. M. BURRIDGE and E. KÄLLEN. Springer, 1984. 273 pp. DM 45.00 (pb).

One of the less appreciated triumphs of science in our time has been the remarkable progress in understanding and forecasting the weather. Over the past decade useful medium range (3–10 day) forecasts based on numerical integration of the governing equations have for the first time become possible. The reader will find a cross-section of the advances which have contributed to this success discussed in *Problems and Prospects in Long and Medium Range Weather Forecasting*. Although some observational and theoretical developments are covered, the most complete treatment has been accorded to numerical modelling. This book is based on a series of lectures given at the European Centre for Medium Range Weather Forecasting (ECMWF), Reading, England, in September 1981. Inevitably, a collection of this sort will suffer from uneven coverage and lack of continuity of exposition; it is fair to judge the work by standards different from those that one would apply to a textbook (for which purpose it is clearly not suitable). The quality of content and exposition reaches a level exceeding that generally expected from such volumes, and there is a good deal of material here that will be of interest to active researchers, advanced graduate students, and those involved in operational weather forecasting.

The book is essentially the sum of its parts, and so this critique will proceed chapter by chapter. There are nine chapters. The introductory one by E. Lorenz deals with general mathematical and physical aspects of the predictability problem. The basic consequences of sensitive dependence on initial conditions are illustrated by means of simple nonlinear difference equations. Professor Lorenz follows this with a survey of predictability results obtained from a hierarchy of more realistic models. Though this is well-trodden material, it never fails to be engaging. The next three chapters make up a lucid exposition of the methodology that has been so successfully applied at ECMWF. L. Bengtsson reviews the history and current state of the art of medium-range forecasting. The progress in the field is best summed up in an example discussed by Bengtsson: the 1951 vintage Swedish barotropic model (state of the art for the time) required 2400 s to produce a 24 h forecast of 500 mbar height, the average error of which was 76 m. A higher-resolution version of the same model runs in $\frac{1}{2}$ s on a CRAY-1, and when initialized with modern data exhibits an error of 47 m. The 1981 ECMWF 15-level operational model, by comparison, takes 1100 s to produce a 24 h forecast with an average 500 mbar error of only 22 m. In the next chapter A. Simmons discusses topics in numerical modelling that are currently under investigation at ECMWF. One finds here a succinct presentation of many aspects of model performance (including comparison of spectral with gridpoint models, and the impact of increasing resolution) that are often alluded to but quite difficult to find in print. The documentation of the systematic-error pattern of the ECMWF model will be appreciated by many readers. It is noteworthy that much of the remaining error in medium-range forecasts consists of this systematic component, which represents model inadequacies, rather than the inherent error arising from the sensitive dependence of the solutions on initial conditions. The prospect for improving forecasts by improving our understanding of atmospheric dynamics is therefore quite good. G. J. Cats treats the initialization problem. One of the more notable findings

reported here is that differences between forecasts starting from slightly different initial conditions distinctly resemble packets of baroclinically unstable waves. The first four chapters fit together well and are written in a readable, self-contained tutorial style. These chapters will be of interest to beginner and expert alike.

The remaining chapters are best viewed as a loosely connected series of research papers. With one exception they deal with issues related to the prospects for long-range (monthly to seasonal) forecasts by dynamical means. Chapters 5 and 6, by J. Shukla, discuss numerical experiments concerning long-range predictability. The former analyses an ensemble of forecasts with slightly differing initial conditions in order to assess the predictability of monthly mean quantities. It is the most extensive study of its type that has appeared at the time of writing this review, though some of the conclusions are compromised by a dubious interpretation of the F-test in an analysis of variance (Hayashi 1985). A lesser problem is that the equation defining F is rendered incomprehensible by a unfortunate typographical error (one of the few in an otherwise well-crafted volume). Chapter 6, which considers the impact of persistent anomalous boundary forcing, is valuable for its unusual scope. Professor Shukla finds something intelligent, and generally quantitative, to say about virtually every boundary forcing that is suspected to be of importance, including such problematic ones as soil moisture and snow cover. Of necessity, this entails a sacrifice in depth of discussion, which is particularly evident with regard to forcing by anomalies of sea-surface temperature. In chapter 7 C. Leith reviews the statistical methodology required for verification of forecasts. This chapter is too condensed to be of much use. There are many definitions but few examples, and the connection with the problems dealt with in the rest of the book is left obscure. Indeed, there is little here that is specific to medium- and long-range forecasting (as opposed to, say, mesoscale forecasting), and one wonders why the editors included this material. E. Källen provides a clear and concise introduction to the multiple equilibrium theory of blocking in chapter 8. The exposition is restricted to barotropic models, which are for the most part severely truncated (though some interesting comparisons with a high-order model are also presented). Theories of this type have attracted considerable attention, and certainly merit space in any book on long-range prediction; one wishes, however, for a more critical assessment of the shortcomings of the theory. The book concludes with a chapter by C. Leith on localized solitary-eddy solutions to the inviscid equations of motion. This is a subject of great importance, because such solutions may explain the persistence of certain atmospheric patterns. Unfortunately, Dr Leith's treatment, while mathematically impeccable, is so terse that it would probably leave the uninitiated reader wondering what the atmospheric relevance is. Critical issues such as generation, maintenance, effects of baroclinicity, the difficulty of finding stationary solutions in westerly flow, and the connection with blocking are scarcely mentioned.

A few of the more successful approaches to understanding the low-frequency variability of the atmosphere are conspicuously absent. In particular, the rapidly growing body of work on Rossby wavetreains and their relation to teleconnection patterns (as in Hoskins & Karoly 1981) is not well represented. One also notices the paucity of discussion of El Niño, coupled ocean–atmosphere models, and simple models of tropical circulations of the sort popularized by Gill (1980). None the less, this book occupies a useful position in the spectrum between textbooks and the archival journals. It will be a source of much thought-provoking reading for several years to come.

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Bilinear Transformation Method. By Y. MATSUNO. Academic Press, 1984. 248 pp. £35.00.

This monograph is concerned with the techniques involved in the application of Hirota's bilinear transformation method, and in particular its use in developing solutions of the Benjamin–Ono (BO) equation. Although there are short sections (mainly in Chapter 2) on the Korteweg–de Vries (KdV) equation, the bulk of the work is devoted to the BO equation and some others quite closely related to it. Bilinearization, Bäcklund transformations, conservation laws and the general inverse-scattering transform (IST) are first introduced for the KdV equation. The BO N-soliton solution is then derived, and the Bäcklund transformation and conservation laws are constructed. The asymptotic form of the N-soliton solution is discussed and a detailed description of the 2-soliton interaction is presented. The finite-depth equation is also written in bilinear form and its N-soliton (and periodic-wave) solution is obtained: this equation reduces to both the KdV and BO equations in appropriate limits, and this is confirmed at numerous stages in the calculations. The bilinearization of various higher-order equations is given in the penultimate chapter.

The approach adopted by the author amounts to presenting a series of mathematical recipes followed by a careful application of the procedures. This has the virtue that many quite intricate calculations are spelt out in detail, generating a useful set of basic results, e.g. N-soliton solutions of various integrable equations. However, the underlying and interconnecting mathematical structure of complete integrability is not at all evident: we are informed of what is to be done, and it is done! Some readers will also find the phrasing rather stilted – I certainly did, particularly when exactly the same combination of words is employed to describe similar calculations time after time. Furthermore, I suspect that only a readership already acquainted with inverse-scattering methods will be able to put this work into perspective.

The author is to be commended in that there are relatively few typographical errors, although a few have crept in on pp. 138, 139, where, for example, the speed of the waves varies from proportionality to V to V^2 to V^3 in the space of a few lines. In terms of the material chosen for inclusion, consistent with the author's theme, I felt that there were a few omissions which might mislead the newcomer and perhaps surprise the old hand. (*a*) The relation between any solutions (or method of solution) and the initial-value problem – albeit special – is only mentioned in passing. (*b*) The 2-soliton interaction for the BO equation could have been usefully compared with that for the KdV equation. (*c*) The periodic-wave solution of the KdV equation derived from the Riemann theta function, and then in particular the soliton limit, is far more easily expressed by using the identity relating theta and Jacobian elliptic functions (see, e.g., Whittaker & Watson, §§22.73). (*d*) It seems a pity that the fairly recent advances in the Wronskian representation of N-soliton solutions are ignored. (*e*) I believe it would have been more instructive to outline the perturbation of the IST scheme rather than the BO equation itself, using classical multiple scales.

Nevertheless, although I do have criticisms, the detailed derivations of and from the bilinear equations will probably prove useful and interesting to students and researchers in the field of completely integrable systems. The price (£35) is perhaps slightly high for a book of this length and with its somewhat limited scope, but there are currently available relatively few books on the IST and certainly no other covers the bilinear transformation method in as much detail. This text could well find a place on the shelves of students of inverse-scattering methods.

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Sea Bed Mechanics. By J. F. A. SLEATH. Wiley, 1984. 335 pp. $59.80.

The structure of flow near the sea bed is of considerable interest to civil engineers, geologists, geographers, oceanographers and marine biologists. In this remarkable book, John Sleath has dived into much of recent years' findings (including his own research) in this field, and has brought a considerable amount of well-organized information to the surface for his readers to contemplate.

Although the structure of the book is very pedagogic, it is much more a handbook than a textbook. This is a compromise, and it is therefore not wholly successful; thus the reader will often seek in vain for a definite judgement on conflicting theories. On the other hand, the structure of the book makes it fairly easy to find a wanted subject, and the accurate presentation of results combined with extensive references gives a good background for private study and further research.

Each chapter (except the one on sediment properties) is divided into three parts: one concerning waves alone, one with currents alone, and one with a combination of the two. Starting with currents might make it easier to introduce the fundamentals, and then the sequence of the three parts would be one of increasing complexity.

In Chapter 1 the basic ideas of wave and current theory are outlined. These also include wave breaking, wave-generated currents and some boundary-layer theory. Linear wave theory is emphasized; in general the wave theories are somewhat loosely sketched. Considering that these theories only cover 14 pages one can wonder why exotic subjects like vocoidal and trochoidal wave theories are allowed to take up one page each. It would be useful to use more space on higher-order Stokes and cnoidal wave theories, and on 'exact' numerical models. Also wave breaking deserves more room in view of the importance of this phenomenon for sediment suspension and transport outside the wave boundary layer. In Section 1.3.1 there is a slip; the boundary layer at the bed is some centimetres thick, rather than 'a few millimetres'.

The author's extensive knowledge of translation to turbulence in the wave boundary layer is reflected in Chapter 2, which deals with fluid velocities and pressures near and in the sea bed. Both oscillatory and mass transport velocities are dealt with. For waves and currents the eddy viscosity theory by Smith (1977) is used for illustration. Most of the results in this chapter (as in the book as a whole) are based on linear wave theory, which is certainly allowable; however, the author is too optimistic when he writes (page 57) that 'the extension to more complicated situations is often relatively straight-forward'. As in most other chapters there is a comprehensive presentation of experimental results, including the author's own efforts.

The short Chapter 3 on sediment properties contains mostly classic stuff, as revealed by the dates of the references. The uncertainty in a prediction of the angle of repose is stated, and a direct measurement of this quantity is recommended.

Near-bed currents, sediment transport, and wave damping are all affected by the bed forms, which is the subject of Chapter 4. It contains very good classifications of bed forms due to waves alone and currents alone, and also instructive sections on the mechanisms of formation, including bar formation on a coast. It is explained why some investigators have not observed three-dimensional effects under waves even at relatively high sediment transport rates: the experiments have not lasted long enough.

Chapter 5 is devoted to bed friction, energy dissipation and forces on bodies on or near the bed. An explanation of the difference between the friction factor and the energy dissipation factor at small values of the ratio of particle amplitude to roughness is presented. A useful comparison between various authors' definitions of an energy dissipation factor is included. One looks in vain for guidance regarding energy dissipation and equivalent roughness at high sediment transport rates over a flat bed, i.e. where sheet flow of the sand replace the ripples.

Only Chapter 5 deals with man-made structures, e.g. submarine pipelines. For waves alone the presentation leans heavily on the experimental work by Sarpkaya. Also the forces on the individual sand grains are studied. The section on waves and currents is also here quite short, and one misses reference to newer work on bed friction such as Grant & Madsen (*J. Geophys. Res.*, vol. 84, 1979) and Christoffersen (*ISVA Series Paper* 30, 1982).

Sediment transport in waves and currents is still an intricate subject with many conflicting theories. This is reflected in the sixth, last and most important chapter of the book. It starts with a review of the numerous expressions proposed for initial movement of sediment in oscillatory flow. It is concluded that Shields' well-known curve for steady flow is also applicable here, when the maximum shear stress based on Kamphuis' measurements is used in the Shields parameter.

The author states that the formulae for bed load in oscillatory flow must be treated with considerable caution, since the data are scarce and not all well documented. It adds to the confusion, though, that at least one of the expressions given in the section on *bedload* applies to *total transport* (Madsen & Grant, 1976). This fact may explain the differences in power on the Shields parameter in the formulae.

Regarding sediment suspension in oscillatory flow the author is quite pessimistic, stating '...that most of the available models can produce reasonable agreement with experiment if empirical coefficients are suitably chosen, but that quite different results can be obtained equally easily'.

Breaking waves are dealt with briefly. Nielsen's important observation of the pronounced influence of surface-generated turbulence on the sediment concentration in the upper (say) 80% of the water depth is reported. Some results for cohesive sediments are also presented.

A very complete compilation of formulae for bedload and total load in steady currents is given, with special comments on the Engelund-Hansen and the Ackers–White formulae.

In the current-plus-wave section the important onshore–offshore transport problem on a coast is given some attention. For longshore transport an extensive list of formulae is presented. It is demonstrated that although the general form of the equations is similar, the scatter of the numerical outcome is enormous. Also the combination of waves and non-wave-induced currents is treated. For the extension of steady-flow formulae (total load) to current-plus-wave situations it is concluded, on the basis of work by Swart (1976) and Willis (1978), that a modified Ackers–White formula gives the best results.

Most chapters have some illustrative examples at the end. All chapters have an extensive list of references; there is also an author and a subject index. The reviewer has found few misprints.

This is a high-level review book in the field of dynamical processes at the sea bed. It has such breadth that it ought to find its way to the library of every marine institute. For students working on projects in this area the book provides a useful basis for further research, and experienced researchers will benefit from using it for reference. They will find the book easy to read, with the qualitative descriptions of complicated mechanisms, for which exact theory is still to be found, being especially attractive.

Naturally, in a book like this there are always subjects which the reviewer finds are missing. Thus there is no mention of the effect of the flow around structures on the bed (erosion, siltation, bed protection), or of the new and important topic ecohydrodynamics, the interplay between living organisms and the flowing water (see for instance Hino, *Advances in Hydrosciences*, vol. 12, 1981, and Vogel, *Life in Moving Fluids*, 1981).

There is still much empiricism in the description of flow phenomena at the sea bed, and there is also plenty of controversy. Thus, calculation of sediment transport on a coast is still at an embryonic stage. However, there is at present much qualified research going on in the field, and in ten or twenty years' time a definitive book on sea bed mechanics will no doubt be written. But to-day the reviewer knows of no better book on the subject than this one.

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